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INSTRUMENT WORK IN AN ATOMIC ENERGY LABORATORY

by

H. U. Fisher

Clinton National Laboratory

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INSTRUMENTS WORK IN AN ATOMIC ENERGY LABORATORY*

By H. U. Fisher

For the past two years I have been associated with the Clinton Laboratories which is one of the Atomic Energy Commission's Laboratories located at Oak Ridge, Tennessee. This laboratory is now engaged in fundamental work in this field mainly because the original Clinton chain reacting pile is there and it is now used as a part of the laboratory where experimental work can be easily performed. In addition, the pile produces the limited quantities of radioactive isotopes that are available for research in industry and medicine. Some of the most prominent scientists in the United States are engaged in the work and as one may easily imagine, quite extensive facilities are required to assist in their work. These facilities include a rather extensive Instrument Department with complete machine shops that must be able to undertake assignments requiring the ultimate in accuracy and often taxing their ingenuity to a great extent. Power house, electrical distribution system, water supply, and transportation are also handled by the laboratories. The remote location makes this necessary.

Prior to 1943 the entire Oak Ridge reservation was Tennessee hills, farms, and stills. I am reminded of a story in which a friend of mine was discussing the value of various brands on the shelves of a package store, with the store proprietor. My friend asked "Is this 'Singin Sam' good." "It is quite reasonable in price," the owner said, "but it is corn and if you are considering the purchase of some let me tell you a story about it. A young man was hitchhiking home from school and was picked up by a man who was alone. As they drove down the road the driver offered the young man a drink. The idea was accepted and the passenger was told that the bottle was in the glove compartment. As the boy picked it up he noticed that it was Singin Sam and he immediately changed his mind and said that he wasn't thirsty and put the bottle back where he got it. At this instant the driver pulled a gun and said in a very commanding manner, 'You, take a drink.' The gun in his ribs caused the young man to select the lesser punishment and he did as ordered. As the bottle was being returned to the glove compartment, the driver flipped the gun and as he poked the butt of the gun at the passenger he said 'Now you make me take one.' "

The actual workings of the Instrument Department are of the most interest to a group such as this and, therefore, I will discuss its functions as well as I can, bearing in mind that security regulations are still in effect and must be adhered to. Each worker at Clinton Laboratories must submit to a thorough examination by the FBI before they can enter the site and begin work. The Commission has the responsibility of keeping secret information in proper hands and it goes to extensive means to do so. Therefore, it will be impossible for me to describe many instrument applications which would be of interest to you.

There are about 80 workers in the Instrument Department and some 25 of them are technical men. The balance are mechanics, electronic technicians, and machinists. This group of people develop and produce instruments and apparatus which cannot be purchased on the open market, service or maintain the installed instruments throughout the laboratory, and select and apply commercial industrial instruments where possible to do so. An example of this will be shown in one of the following slides.

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*Illustrated talk delivered at the Short Course on Instrumentation, Texas A and M College, College Station, Texas, August 1947. (Slides used with talk are given as figures.)

Before we can discuss some of the applications, it would be well to describe some of the measurements which our instruments are capable of making. The most important one is the measurement of radiation and of course this field is quite comprehensive. Radiation occurs in a number of forms — alpha, beta, gamma, neutron, and X-rays. For this discussion we will consider only the first four and the X-ray will be left to others, since our work had very little to do with it.

The first three types have properties which make it possible to measure directly while the neutron is measured indirectly. Strictly speaking, this is not true as far as gamma radiation is concerned but we can consider it so for the present discussion. In general, alpha, beta, and gamma radiation will ionize a gas as it passes through it. This ionization produces a current in an electrical circuit which is measured or in other cases each particle or ray will cause a negative pulse in an electrical circuit which can be amplified and counted electronically.

Before it is possible to measure the current indicated or to count the pulses mentioned we must have the unit designed which contains the ionizing gas and has the electrical connections which are necessary. These units are called ionization chambers or counters. The general design of both includes a gas chamber designed for a specific volume according to the use to which the chamber is to be put, and a high voltage center wire well insulated from the remainder of the chamber. The low voltage is the shell in most cases. Our department is called upon to design and build these chambers and many are very special.

The counters, which are of three general types, are used in the laboratories to determine the activity of prepared samples. It should be adequate to mention here that the four radiations indicated here are absorbed differently and, therefore, this fact must be taken into account when using a counter. This also accounts for the three general types. One is capable of counting the stronger alphas and some of the betas, another counts the stronger betas, and the third is for gamma only. I think it is obvious that gamma radiation can be measured by all three types and betas are also counted by the first type. The alphas are most easily absorbed which is indicated by the fact that they will not penetrate a sheet of bond paper, betas are next and they can generally be absorbed by one inch thickness of soft wood, whereas the average gamma requires 2 inches of lead to reduce its energy to a low level. Actually the absorption of gamma is an exponential function and theoretically it can never be entirely absorbed. Neutron counters are made, too, but we will discuss them a little later.

The first slide (Figure 1) shows two views of the mica window counter or the first of those just described. This counter is made completely by the instrument department. It consists of a brass shell sealed at one end by a plug containing a Kovar seal and a flange on the other end upon which the mica is cemented. The center wire is carried through the Kovar seal to within 1/16 inch of the mica. A glass bead is put on the end of the wire to reduce the possibility of arcing. The capillary tubing at the top is for evacuating and filling. The counter is then sealed on the high vacuum system where it is evacuated to a pressure of about 1×10^{-6} millimeters of mercury absolute. If it were possible to obtain a higher vacuum we would like to do so. Each atom of elements other than those wanted in the counter, affect its efficiency. After evacuation, the counter is filled with some pure noble gas to a definite pressure well below atmosphere. These counters are made self-quenching by addition of an organic vapor which is the factor governing the life of the counter. Most of them will operate until about 10^8 counts consume the quenching vapor, after which they can be cleaned and refilled. The reclaiming operation includes the installation of a new mica window.

These counters are built in an air-conditioned room and three main problems are encountered in the construction. Cleanliness is essential and when the mica is cemented on the flange we must be absolutely sure that no dust particles are in the cylinder. Very small amounts of dust, moisture, or anything at all will prevent its operation. The center wire of tungsten, about 7 mils in diameter, must be absolutely straight and exactly centered in the cylinder. To achieve this condition we have built a wire straightening machine which heats the wire in a vacuum and pulls it straight. The third problem is that of cementing the mica on the flange. Our solution to this problem is the selection of a gelva resin as the adhesive.

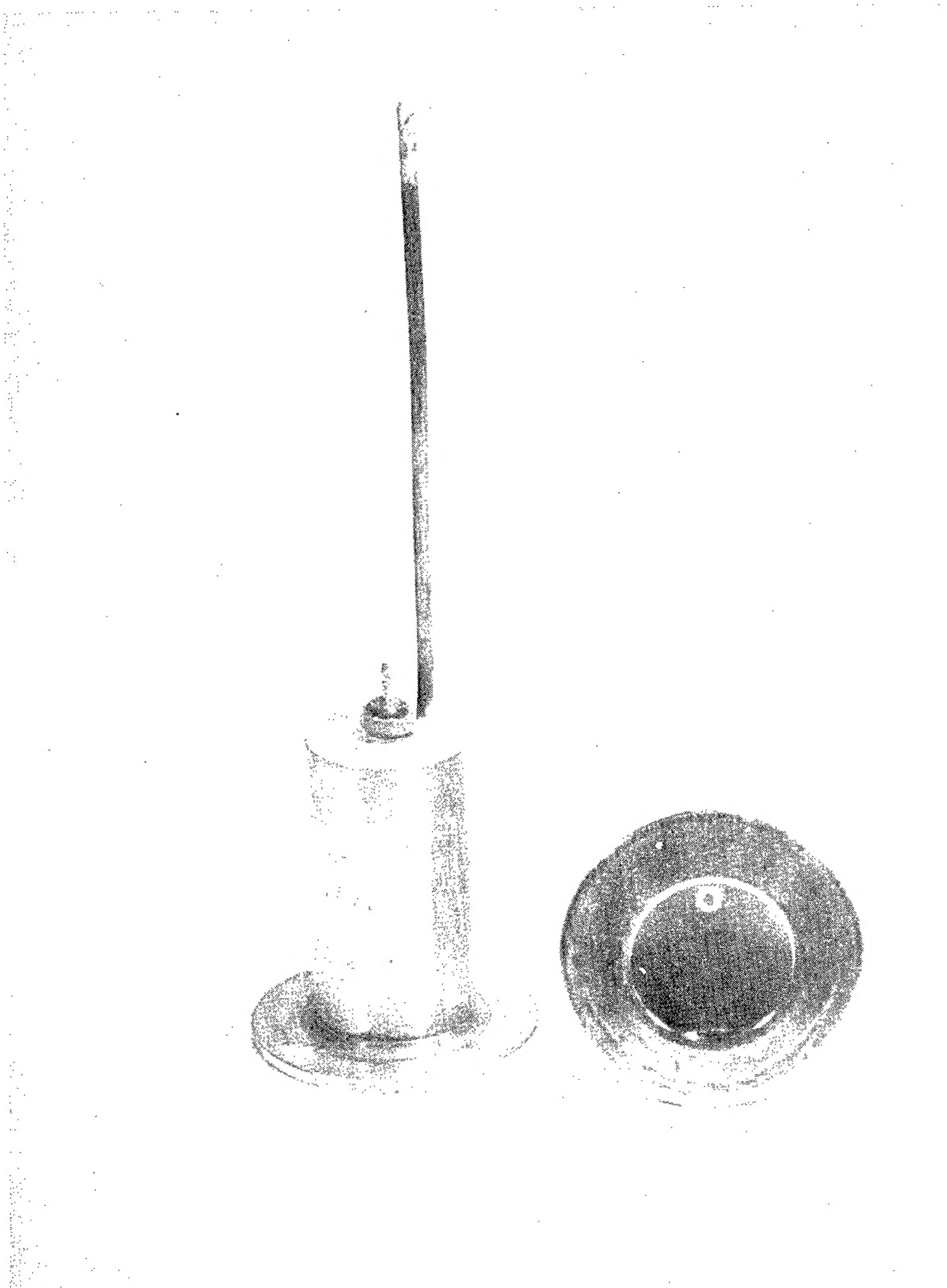

Figure 1.

Our mica is purchased as the best ruby mica available. It comes in sheets about 4 inches square and 1/16 inch thick. The sheets are split with a sharp steel needle under water until the final window is about .0005 of an inch thick. The windows are then measured and weighed so that the absorbing qualities in milligrams per sq cm are known to the researcher using the counter. Our weights vary from 2.4 to 3.7 milligrams per sq cm. Before cementing on the flange each mica window is inspected under a polariscope for strains or flaws which might cause the window to pop when the unit is evacuated. Each failure which occurs when the counter is on the vacuum header results in particles of pulverized mica being plastered over the entire insides of the system. This often causes the counters to fail when tested and we have trouble for some time.

The use of high vacuum equipment throughout the laboratory requires considerable attention. The most useful device for this purpose is the helium leak detector built by General Electric and Westinghouse. It is a mass spectrometer set up for the mass of helium and capable of determining minute quantities of helium. By passing helium over the vacuum piping and apparatus, we can determine small leaks which cannot be located in any other manner. These units are portable and can be attached to any apparatus for testing.

Absolute pressures in the range below 1×10^{-5} millimeter of mercury are quite difficult to measure. The McLeod gauge is satisfactory down to this value but not any further. This gauge is simple and does not require electronic circuits. Its chief disadvantage is that it does not give continuous readings.

A Knudsen gauge operates on momentum of impact of gas molecules against an aluminum vane. The range is 1×10^{-3} to 1×10^{-5} mm Hg abs although some have been calibrated as low as 10^{-7}. This device gives a continuous reading, is slow to react to pressure changes, only needs one calibration for all gases, and the metal shell really presents a problem in outgassing.

The Pirani gauge employs the fact that thermal conductivity of a gas is related to its pressure in the range of 10^{-2} to 10^{-5} mm Hg abs. This gauge has a simple electrical circuit, it is sensitive to rapid changes in pressure, but it is temperature sensitive, and needs calibration for different gases.

The thermocouple gauge uses about the same principle as the Pirani. The tube consists of a heater and thermocouple tied to one junction. Current is passed through heater and emf of thermocouple varies with pressure. Range is 10^{-2} to 10^{-4} mm Hg abs or slightly less than the Pirani. Advantages and disadvantages are about the same as the Pirani except the tubes are a little cheaper.

The ionization gauge is probably the most desirable for measurement since it covers the widest range, 10^{-4} to 10^{-7}, although it has been used down to 10^{-10} mm Hg abs which is about the lowest pressure ever recorded. It is purely electronic in that the gas molecules at the pressure being measured are ionized and collected on the plate of a triode. The current which results is a function of the pressure in the tube. This gauge must be calibrated and thoroughly outgassed. The unit can be easily damaged if not properly used.

All of our counters use the high vacuum system for evacuation before filling and the next type is the type used for counting stronger betas. This counter, shown in the next slide (Figure 2) is not made at Clinton Laboratories. The glass work is contracted for with such concerns as Eck and Krebs Co. and H. S. Martin Co. It consists of a glass shell about 20 mm in diameter and an overall length of about 8 inches, including the leads. The center section of about 3 inches in length is drawn down to a thickness of .006 inch to prevent absorption of the form of radiation which is being determined. This section is silvered on the inside for the electrical conductor and the low voltage connection is brought in through the off center connection to the silvered surface. The high voltage wire of .004 inch diameter tungsten wire is through the center, sealed at each end. We only seal the tube on our vacuum system and evacuate, then fill much the same as we did with the mica window counter.

The gamma counter is the same as the beta except the thin wall section is changed to a thickness of about 1 millimeter which will only pass gamma rays. Special gamma counters of brass or other materials are often made for experiment which cannot use our standard counters.

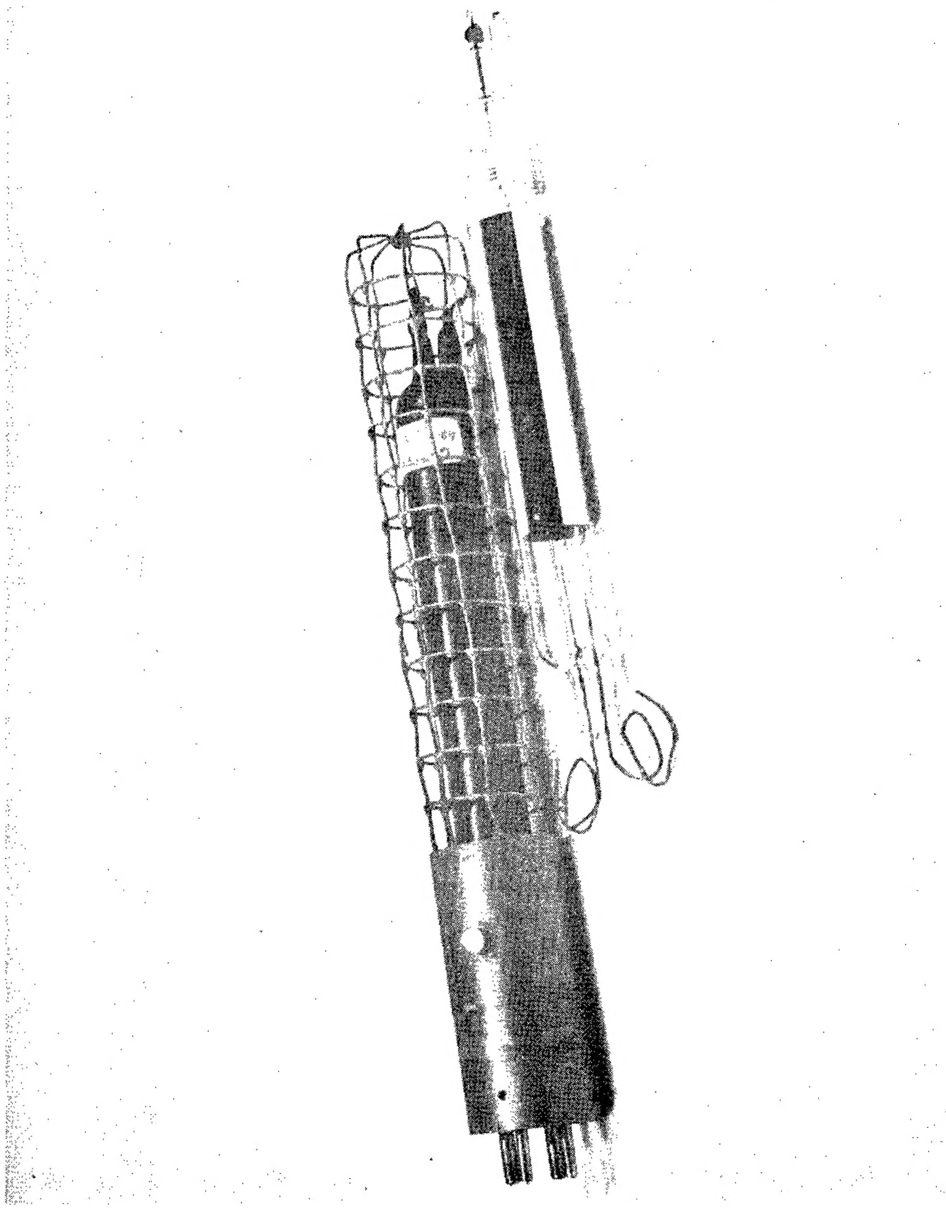

Figure 2.

Neutron counters can be described briefly. The reaction which is used in the slow neutron counter is as follows:

$$_5B^{10} + {}_0n^1 \longrightarrow {}_3Li^7 + {}_2He^4 \text{ (alpha particle)}$$

When a neutron enters the Boron 10 nucleus, there is a transmutation reaction and lithium is produced with the emission of helium or alpha particle. This of course is a strong ionizing particle and produces the effect which can be counted. Boron in the form of boron trifluoride gas is used as the filling gas. Only the B^{10} isotope enters the reaction and since boron exists naturally as about 85% B^{11} and 15% B^{10}, the efficiency of these counters is low unless an isotope separation can be made to enrich the B^{10} content.

When counters are finished they are checked with a known radioactive sample. A graph similar to that shown on the next slide (Figure 3) is drawn for each counter. The plateau must have less than a 5% rise calculated in the manner shown on the slide. Most of them, however, are about 2%. The plateau must be at least 180 volts in length or the counter is rejected. The figures given on the slide apply to mica window and standard glass counters but do not apply to neutron counters.

We logically come now to the electronic counting equipment which can use the signals from this equipment. Many standard counting units are available for this purpose but we still build our own because no one has as yet seen fit to develop a single unit which will include the high voltage supply for the counter and an input circuit which will handle a wide variation of pulses. The counting is accomplished by an electronic circuit of a series of stages, each stage receiving two pulses and delivering one to the succeeding stage. This gives a halving of the number in each successive stage until the rate is reduced to a frequency of less than 30 per second which can be picked up by a mechanical type of register. A scale of 64 is commonly used which means that 64 counts are required to make one show on the register. Scales as high as 4096 are sometimes required for measuring samples having high rates of disintegration. The next slide (Figure 4) shows a checker using a water counter and making sure that our laundry water is not dangerously contaminated. The counter is in a pipe which is placed in the container of water being tested. It is connected by high tension shielded cable to the scaler. It is a scale of 64 as indicated by the 6 interpolate lights on the upper part of the panel to the left of center. The meter on the panel indicates the high voltage on the center wire of the counter. The operator has a switch in her left hand which operates the timer just to the right of the scaler. The register is next to the timer. The scaler and timer are switched on simultaneously and at the end of a selected time both are stopped, usually 2 or 3 minutes. The register difference times 64 plus the number under the lighted interpolate lights gives the actual count. The scaler uses 115V 60 cycle AC and requires about 150 watts of power.

Absorption of radiation has been discussed and one of the interesting parts of our work at Clinton Laboratories is the operation of equipment behind shields which act as absorbers and protect the workers. The shields are lead walls, concrete walls, or sometimes water. Solutions can be transferred by steam jet vacuum arrangements; liquid levels are indicated by manometer type instruments connected to gas bubbler systems and specific gravities are measured by differential manometers and gas bubblers. That sounds just like anyone's plant but all of the apparatus is washed with acid and water at regular intervals to decontaminate it. The equipment must stand this treatment and it must be reliable because if repairs are needed, they are costly. For example, when a repair is required on any apparatus within one of the cells, it is first necessary to decontaminate before anyone can enter the cell at all. The acid and water treatment is controlled from outside. A measure of the radiation level is made with portable instruments which will be described later. From these readings the members of the Health-Physics Department can determine the safe working time for an individual so that he will receive less than a tolerance dose of radiation for that day. This time may vary from one or two minutes to hours and when the job time has been estimated, it is easy to determine how many men will be needed to complete the job. On short safe working time jobs, it is often necessary to obtain workers from all occupations in order to complete it. Each worker receives instruction as to what to do and he

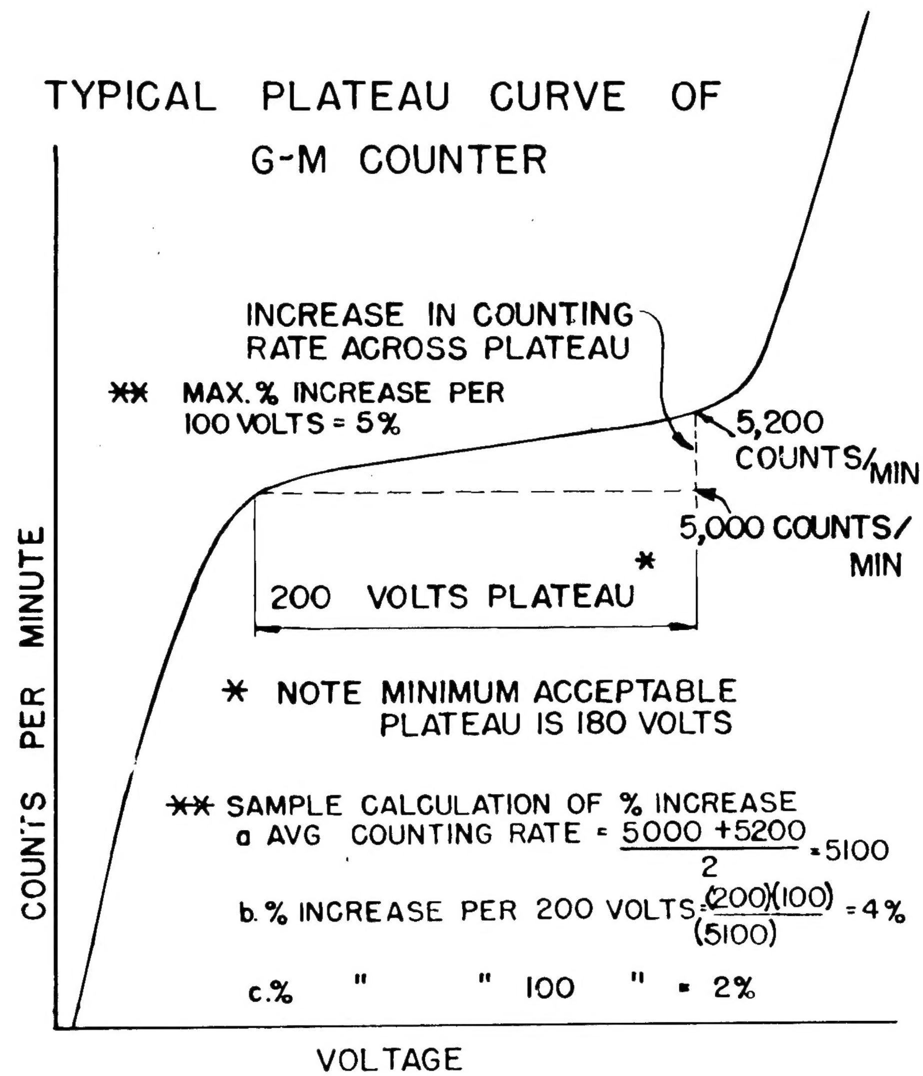

Figure 3. Typical plateau curve of GM counter.

is timed carefully while in the cell. Then for the rest of the day the worker is placed where there is no possibility of exposure. One can readily see that such procedures are slow and expensive and for this reason we try to prevent them by proper installations.

Instruments which require some attention, and most of them do, are never placed in the cells because if trouble develops we are forced to discard the unit and install a new one. Installations are complicated as a result and our ingenuity is often taxed in working out a satisfactory method. Periscopes and telescopes have been designed to enable the operators to see what is happening in the cells. These instruments are sealed with water in many cases to protect the eyes of the operator and they are operated by motor very much as guns are controlled. In one case a television set was used so that the operator could see at any moment that the cell equipment was operating as it should.

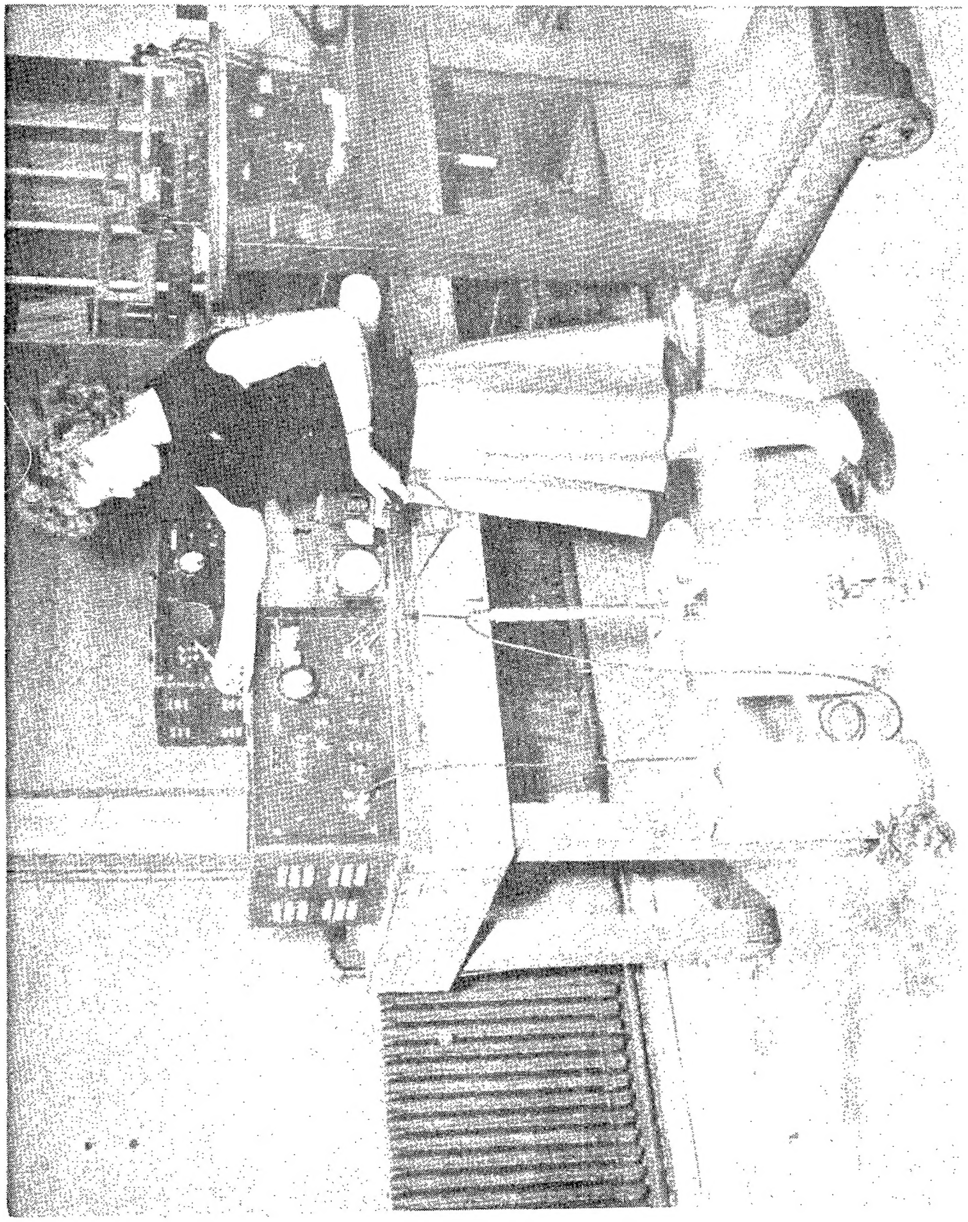

Figure 4.

I will now mention a few special instruments used or developed at Clinton Laboratories.

The first two instruments have been perfected by C. B. Pickle, a Texan from Port Arthur and Texas University. Both instruments have declassification requests held up because of patent condition but I can describe them briefly.

The next slide (Figure 5) shows a voltage regulator for electroplating control. The purpose in showing this view is to give some idea of the type of work our electronic section produces. Unfortunately, circuits will not be discussed until the declassification is completed. In Mr. Pickle's words, "This regulator is a servo-mechanism incorporating a DC amplifier and motor drive for furnishing DC potentials as great as 12 volts and currents as great as one ampere with the voltage regulated and maintained to within plus or minus 3.5 millivolts under load conditions that change several hundred per cent over a period of 24 hours.

"Being able to maintain plating voltage with this accuracy has permitted a new and useful electrical separation process to be developed, whereby one element and one element only is removed from the plating solution.

"The electroplating method is a three electrode method using a cathode, probe, and anode. The front panel controls and meters merely permit measurement of all potentials and currents involved, and balancing of the DC amplifier."

The next slide (Figure 6) shows the latest development of the Fluorophotometer. This instrument is the development of two men. The one shown, however, is Mr. Pickle's final perfection and since its application in research is so widespread we have requested its declassification so that it will be available to everyone. The patent situation is not settled as yet and therefore we must limit our description accordingly. Again Mr. Pickle describes the instrument and its applications as follows:

"The Fluorophotometer is for the measurement of the intensity of fluorescences of chemical elements, when the elements are excited by invisible ultraviolet light. The accuracy of the instrument is such that it has proven invaluable as an analytical tool and is now in the same category as the semimicro balance. For one particular element the quantity of the element present in the sample measured, in the 1 to 2×10^{-10} gram range, can be determined with an accuracy of 10%."

The vibrating reed electrometer is an instrument which was developed during the war by the Manhattan District. It was not developed by Clinton Laboratories but is used there. This instrument has replaced the FP-54 electrometer tube and G. E. circuit in many of our applications. It is capable of use to measure circuits of 10^{-17} ampere which is a current of about 60 electrons per second, with about 1% accuracy either by a drift method or with a resistor known to 1%. A slide showing this instrument is not available but the vibrating reed or condenser is a precision unit operated in an inert atmosphere with the amplifier separate. The vibrating reed electrometer is essentially a potentiometer in which the unbalanced voltage is detected by the precision built vibrating air condenser and coupled by a fixed air condenser to an AC amplifier. A Brown Electronik flight recorder can be used to record the readings. For detailed information about this instrument I suggest that you write Atomic Energy Commission in Washington, D.C. for the declassified or unclassified reports which describe "The Vibrating Reed Electrometer" as designed by the Argonne National Laboratories.

An example of an unusual request of the Instrument Department is that of building an arc source for arcing specially prepared samples. A spectroscope with camera attachment is used to photograph the results of arcing the sample. The photograph then is interpreted by the spectrocopist and quantitative elemental determinations are made. Requests for this type of apparatus varies with the samples to be analyzed. Some are AC, some DC and they may be high current or low current units.

I have mentioned our Health-Physics Department. This department is performing a wonderful job and one which is very important. They study the measurement of radiations from the standpoint of human beings and its effect on them. Radioactivity is an insidious thing because it cannot be seen, heard, or felt at the instant when damage can be experienced. Therefore, someone must be surveying

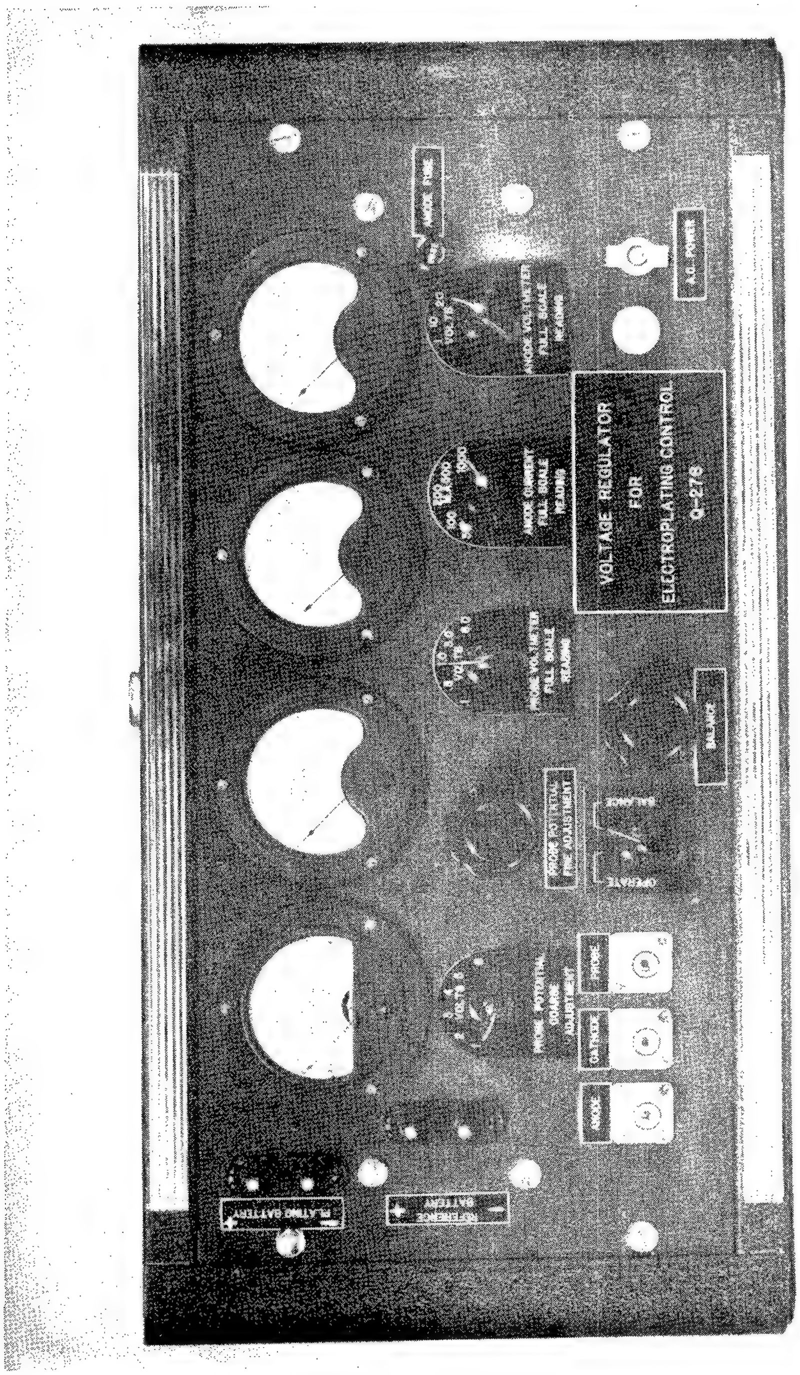
VOLTAGE REGULATOR
FOR
ELECTROPLATING CONTROL
Q-278
ANODE VOLTMETER FULL SCALE READING
ANODE CURRENT FULL SCALE READING
PROBE VOLTMETER FULL SCALE READING
A.C. POWER
BALANCE
OPERATE
PROBE POTENTIAL FINE ADJUSTMENT
PROBE POTENTIAL COARSE ADJUSTMENT
ANODE
CATHODE
PROBE
PLATING BATTERY
REFERENCE BATTERY

Figure 5.

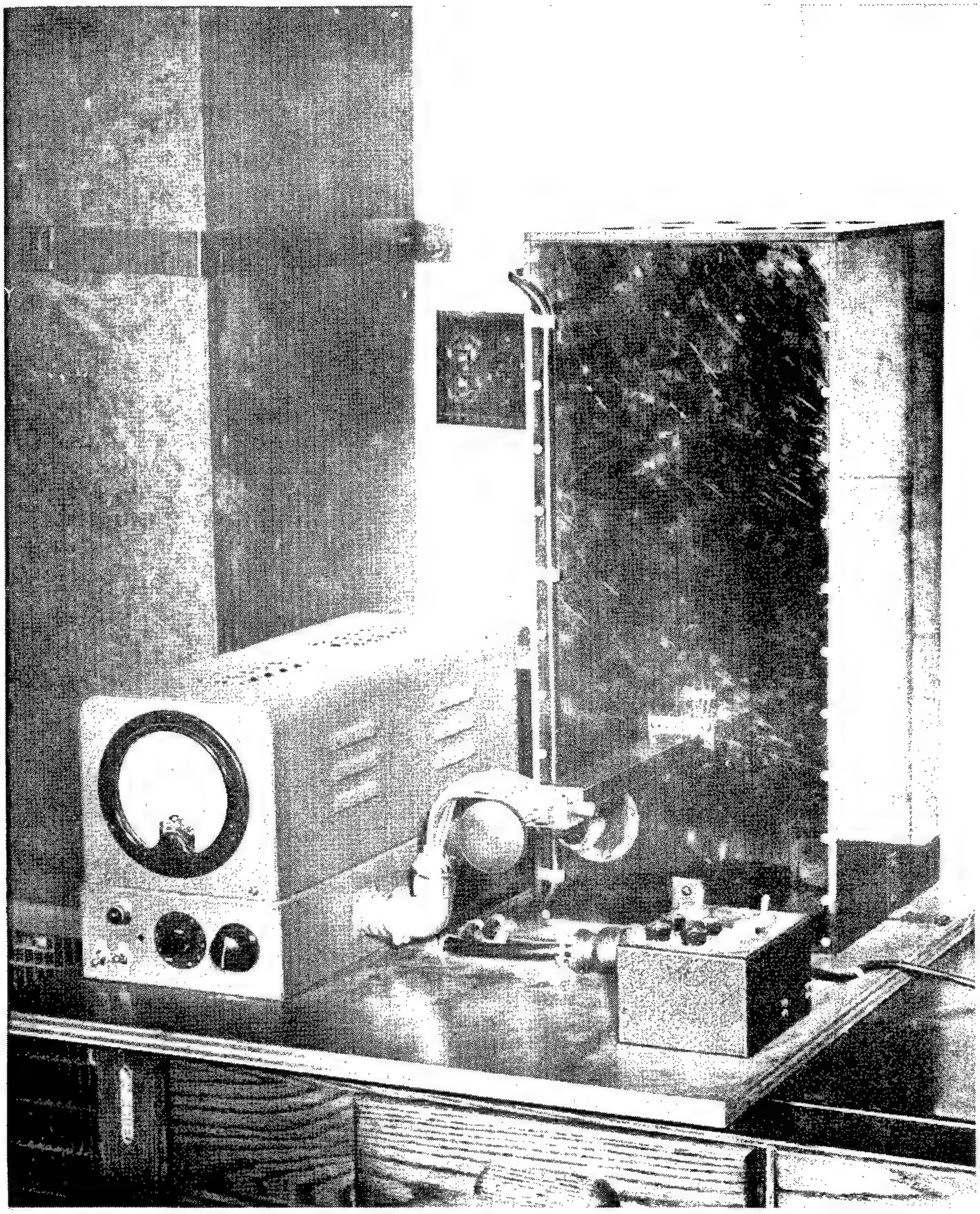

Figure 6.

continually to locate activity which could injure someone. For this use a number of instruments have been developed and are in continual use. From the foregoing comments one can readily understand that one instrument cannot read for all types of radiation and a number of them are needed.

In the case of alpha we need only to concern ourselves with preventing the particles from being breathed by the workers. Where possibility of this exists we continually sample air and count particles deposited on a filter paper or collected by means of a precipitron. The danger to the individual in breathing alpha is that the material will continue to irradiate within an individual's respiratory system without it being known and considerable tissue damage could result. The other forms of radiation are not so likely to have the particles enter the human body and here the damage will result when the person is exposed and only then.

The Health-Physics group at Clinton Laboratories have been quite successful in protecting our workers and their methods are responsible. For example, each worker, whose duties present any possibility of exposure, is required to wear two pocket ionization chambers and one film badge all the time they are on the site.

The next slide (Figure 7) shows in some detail the construction of the pocket meters which are about the size of a fountain pen. The slide shows three types and the one in the center was the original made by the Victoreen Company. The meter consists of a plastic shell with a coating inside of aquadag to make it conducting. Each end is fitted with a polystyrene insulator through which the center electrode is passed. The cap on this unit is screwed on and protects the center wire from striking an object which might discharge it. The Victoreen plug-cap meter on the right is their more recent design and is more satisfactory. It does not discharge as easily because of its construction and the cap is provided with a taper to fit in the shell by friction rather than screw on. The frequent unscrewing of the cap in the original model was a main source of trouble because the threads would not hold up.

The meter on the left is one designed by our Chicago site. It differs from the others mainly in that it has a conducting plastic liner for the shell which prevents need of coating the shell. The coating does not stay on too well and when it flakes off we have trouble.

The instrument shown in the next slide (Figure 8) is a Minometer built by the Victoreen Company. It reads the residual charge on a pocket meter after it has been worn by an employee for one day and from this reading it is possible to determine the approximate radiation which has passed through the meter. The second meter is worn as a check on the first. After the residual charge has been noted the operator recharges the unit and it is ready for the next user.

The film badge is shown on the next slide (Figure 9). Two kinds of film are used, neutron and gamma. The slide indicates two types of gamma film which are indicated as sensitive film and insensitive film. The sensitive film has a low range for smaller amounts of exposure, while the insensitive film will only indicate greater amounts of radioactivity. Both types are loaded into the film badge which is worn by the employee as any other badge.

The densitometer shown in the next slide (Figure 10) is our means of accurately reading the variations in the film. The Health-Physics group can convert the reading of the densitometer to actual units of radiation exposure.

A view of our clock alley on the next slide (Figure 11) indicates how our meters and badges are distributed to the employees. As the employee enters the door at the right coming toward the camera he picks up any pair of pocket meters in the lower rack near the guard. These pairs are selected by the Health-Physics personnel as they charge them. Pairs are equally or nearly so in their original charge. As the employee passes down the aisle he finds the film badge corresponding to his payroll number. Upon leaving the plant he deposits both pocket meters and film badge in the spaces provided in the upper racks. After work hours the Health-Physics people measure all pocket meters and only when some indications result, do they develop the film. However, each film badge is developed and reloaded every two weeks.

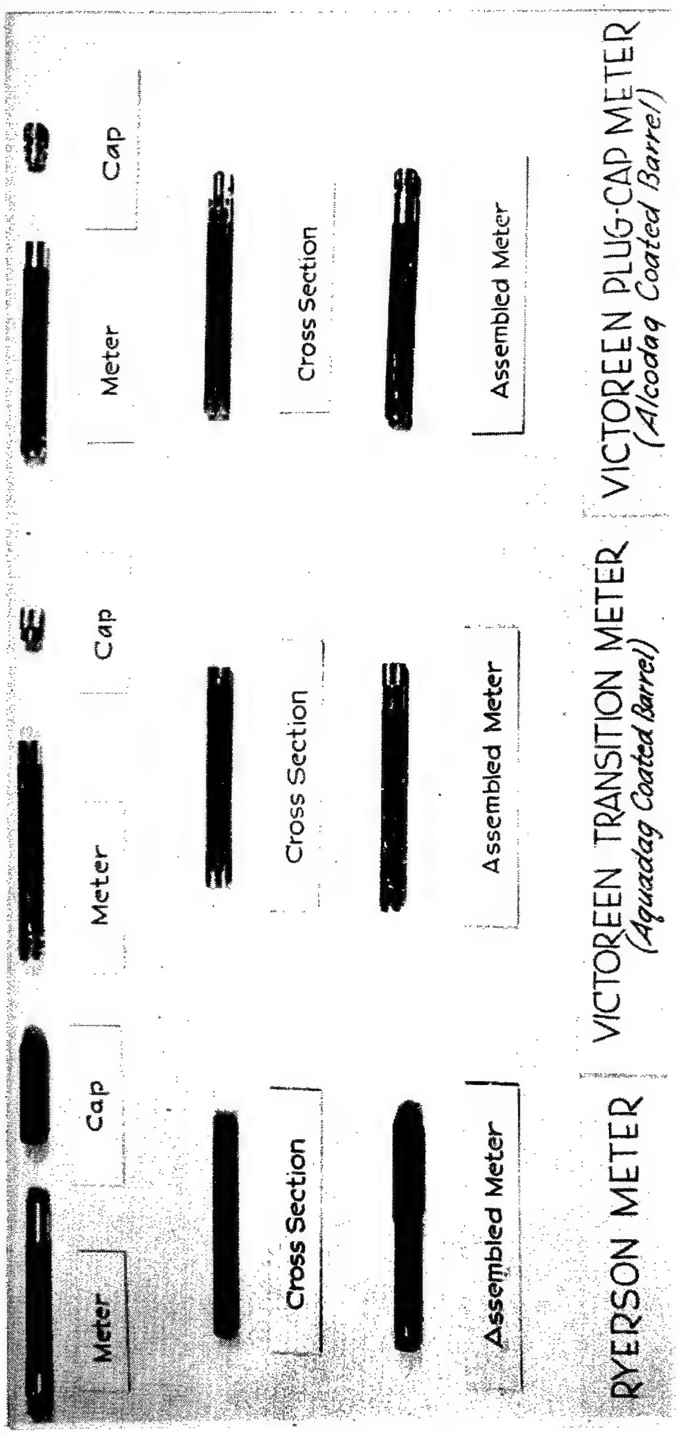
Meter
Cap
Cross Section
Assembled Meter
RYERSON METER
Meter
Cap
Cross Section
Assembled Meter
VICTOREEN TRANSITION METER
(Aquadag Coated Barrel)
Meter
Cap
Cross Section
Assembled Meter
VICTOREEN PLUG-CAP METER
(Alcodag Coated Barrel)

Figure 7.

Figure 8.

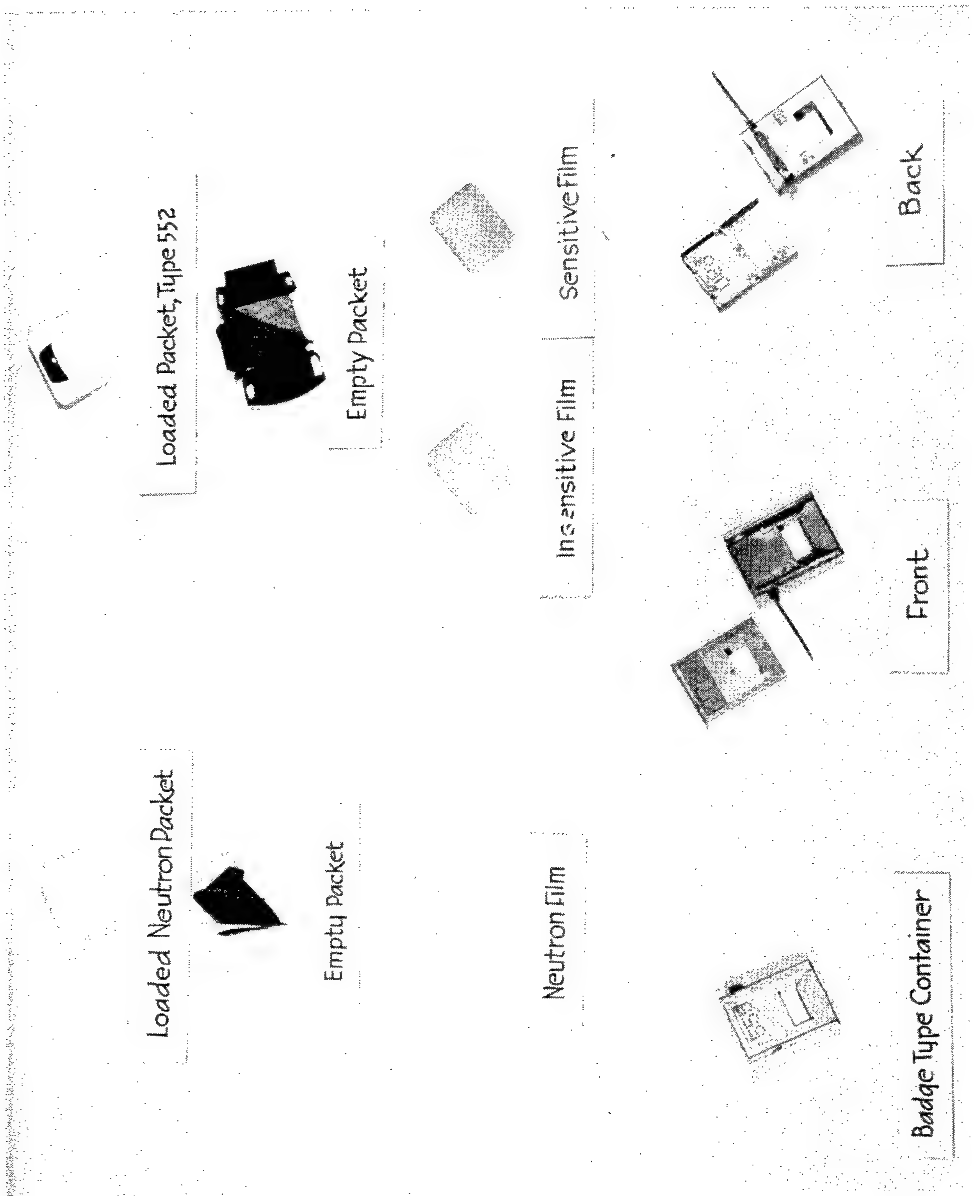
Loaded Packet, Type 552
Empty Packet
Sensitive Film
Insensitive Film
Back
Front
Loaded Neutron Packet
Empty Packet
Neutron Film
Badge Type Container

Figure 9.

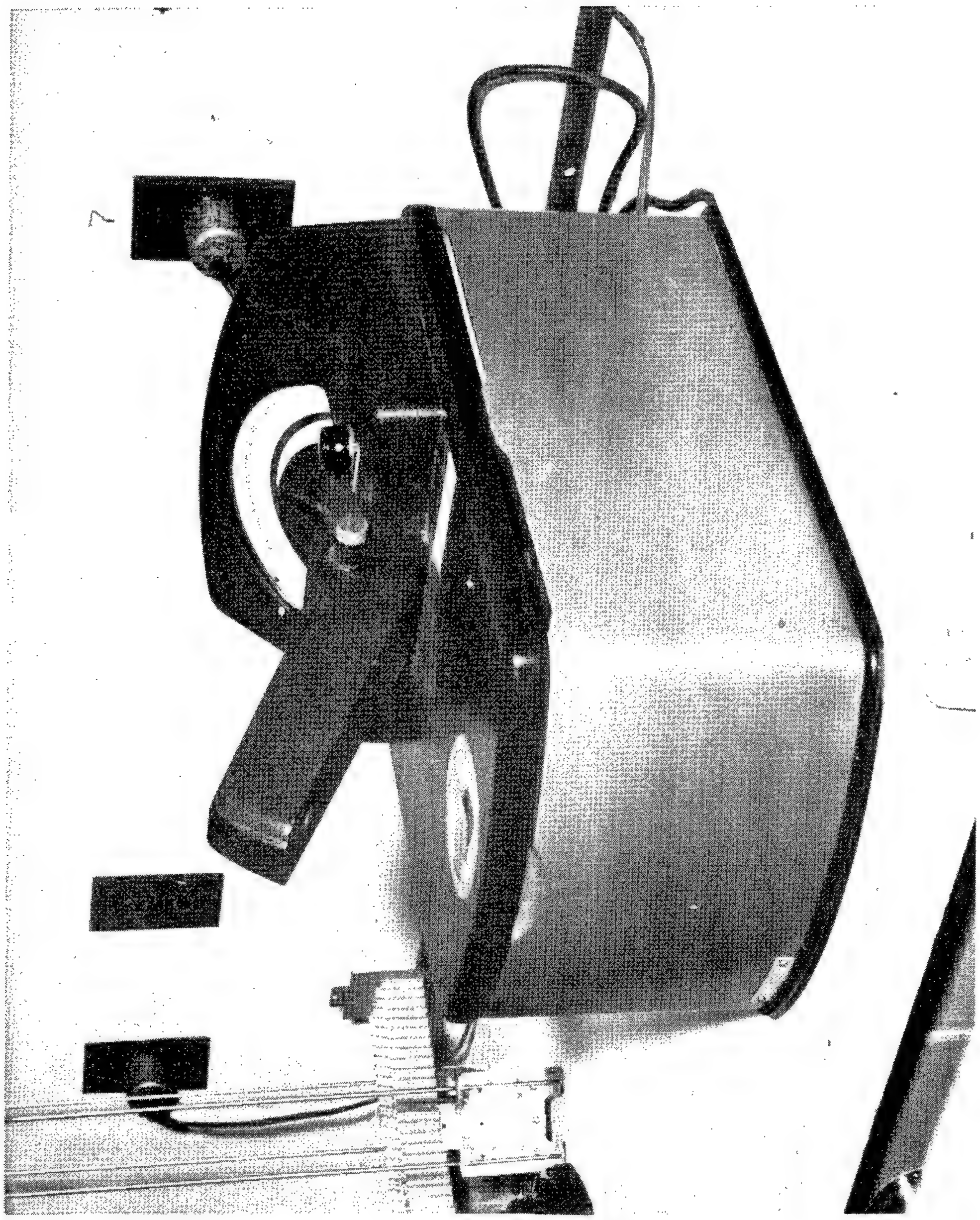

Figure 10.

I have mentioned that our work often included the application of commercial instruments to this special work. The next slide (Figure 12) shows some examples of this. The equipment pictured is located in one of our area monitoring stations. In the foregoing at the left is a scale of 64 scaler connected to a counter not shown in the photograph. This standard scaler differs from the last one pictured only because it is connected to an ordinary traffic counter which gives us a record with reference to time of the radiation at the counter. To the right is an amplifier which receives its signal from a chamber outside the photo and records on the Leeds and Northrup instrument in the center behind the traffic counter. This combination of units is called a Victoreen Integron. The chamber contains a motor driven modulating condenser which is charged at regular intervals. As radiation ionizes the gas in the chamber the charge on the condenser leaks off and the residual charge is measured through an amplifier and indicated on a meter on the panel of the amplifier. The same reading is also recorded on the Leeds and Northrup recorder. The condenser is recharged every 8 hours and if the radiation exceeds a given amount an alarm is sounded and the condenser is recharged. This particular set up is quite generally used at Clinton Laboratories. All work areas are monitored in this fashion and in the vicinity of the chain reacting pile we have a number of them installed. The alarm in each of these is connected to shut down the pile if the radiation exceeds the set amount.

The next slide (Figure 13) is not a very satisfactory picture but we found it hard to obtain one of this detector. Spaced around the doorway are 5 thin wall counters. These counters are connected to a special 5 channel scaler. The rate at which counts come into the electronic device registers on a meter and a close approximation of the activity can be noted. When such a device is seen on a doorway it indicates that radioactive material must not pass through the door. To closely guard the situation we have all of them equipped with alarm bells to warn anyone who may be careless. Clock alleys, all entrances to certain buildings, and special places are so equipped. The doorway shown is in the instrument shop because we must be extremely careful about bringing activity into our building so that the background of our chambers and counters is as low as possible.

The next slide (Figure 14) shows a portable alpha checking instrument. It is equipped with a rather long cable, about 18 ft. The chamber at the end of the cable has a plastic pistol grip handle with an indicating meter. The cabinet contains the amplifier. The probe or chamber lies on top of the cabinet. Laboratory surveys are made with the probe which has a nylon window about .0002 inch thick to permit passage of alpha into the chamber. Detection of radiation is picked up and amplified and sent out on a loud speaker. The frequency of the "Pops" on the speaker indicates the rate of radioactivity. The meter on the handle is also a measure of it. This instrument is very popular among the research workers because it can be left in operation and it will warn immediately of any change in activity in such a manner that one is conscience of it very readily.

The instrument used for survey work to measure beta and gamma is shown on the next slide (Figure 15). It is a compact unit operated entirely by batteries and using a single sub-miniature electrometer tube in the DC amplifier circuit. The nose or barrel on the right is the ionization chamber. A hinged window in the end of the chamber permits the operator to change absorbers and thereby measure either beta or gamma. Seven small batteries are required and three ranges are used. Ranges are selected by switch which changes the imput resistor, the three values are 10^9 ohms, 10^{10} ohms, and 10^{11} ohms. The electrometer tube and the input resistors are all mounted carefully and coated with ceresin wax to prevent surface leakage. This instrument has just been declassified and it was developed at Clinton Laboratories. Before long it will be available on the market. The slide shows the calibration chart for all three scalers. The reading of the meter in microamperes is converted to radiation units on this chart.

The next slide (Figure 16) shows a very similar instrument to the last one described. Here the chamber is in the bottom of the case and various absorbers are provided in slides so that all forms of radiation can be checked. This instrument uses a balanced amplifier circuit with two tubes and the meter measures the drop across the unbalanced circuit whereas the meter in the instrument on the last slide measures the plate current in the one tube.

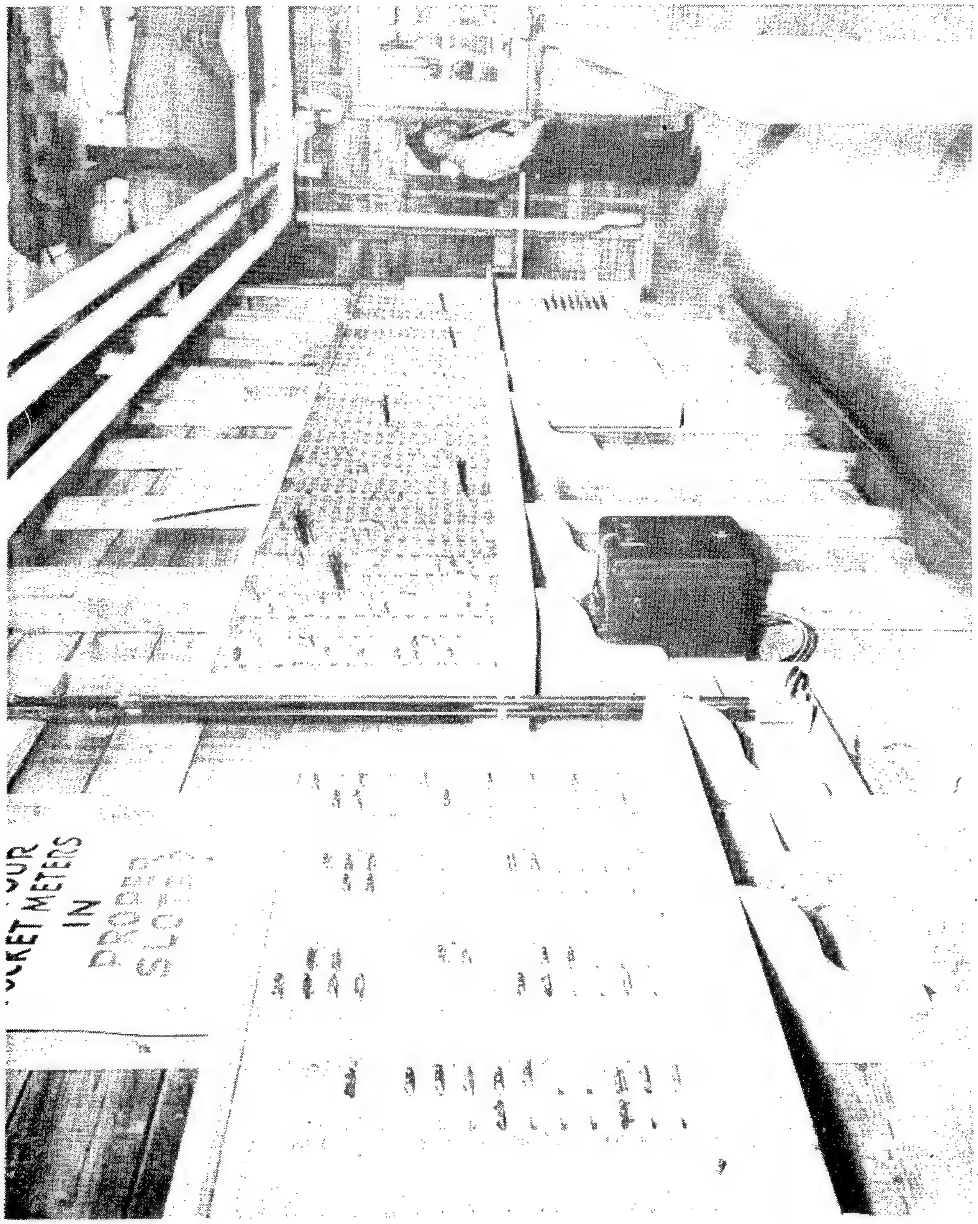

Figure 11.

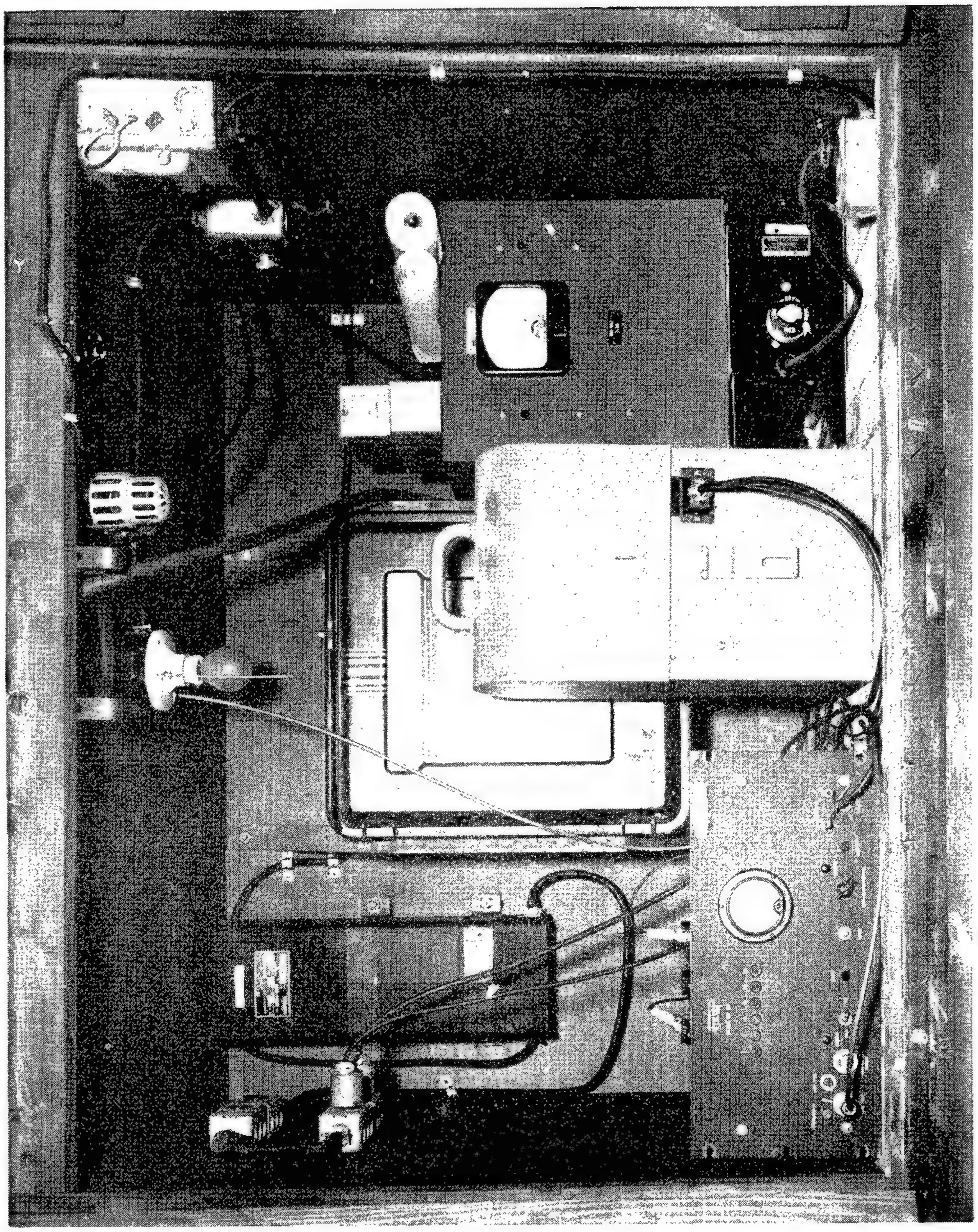

Figure 12.

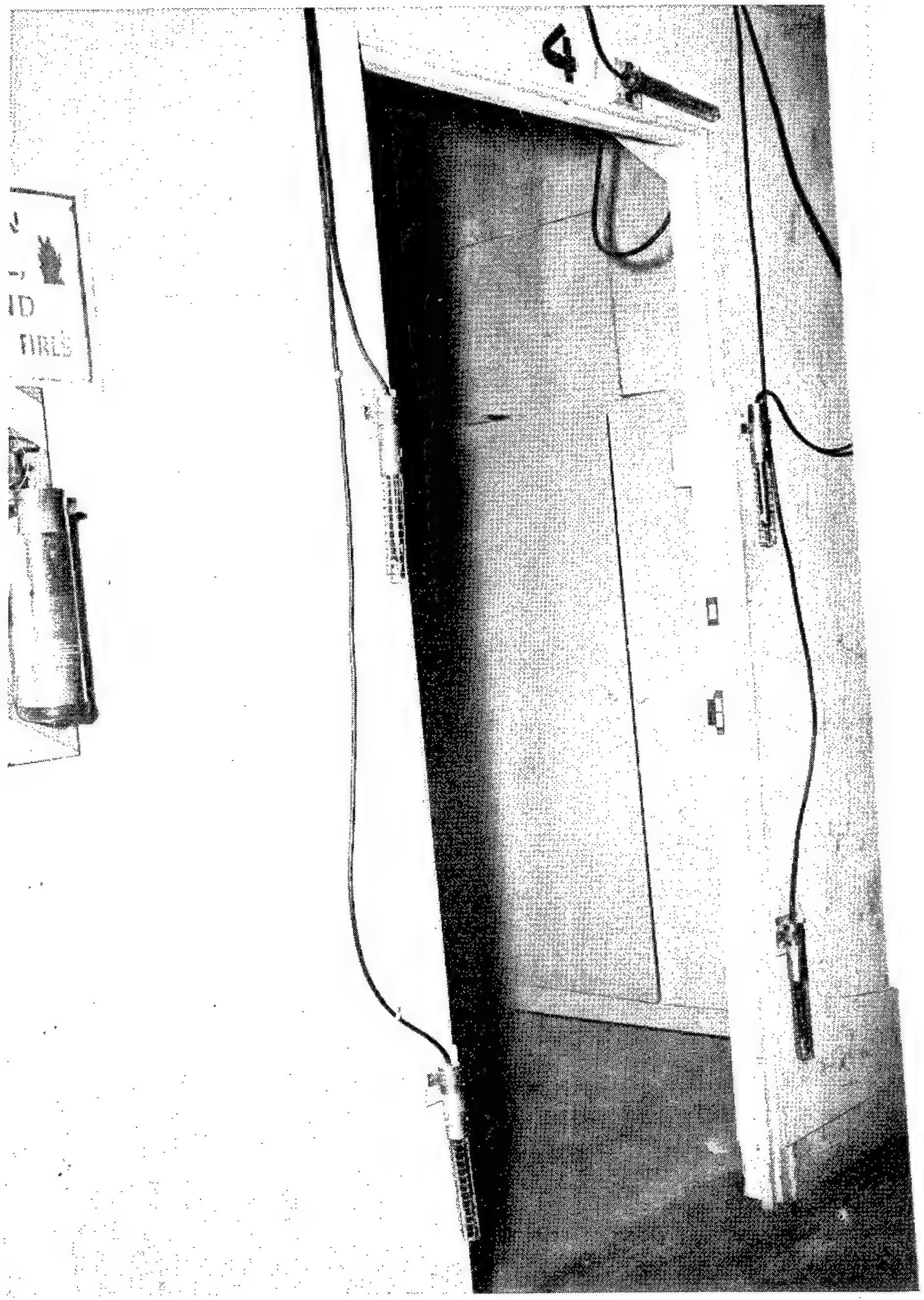

Figure 13.

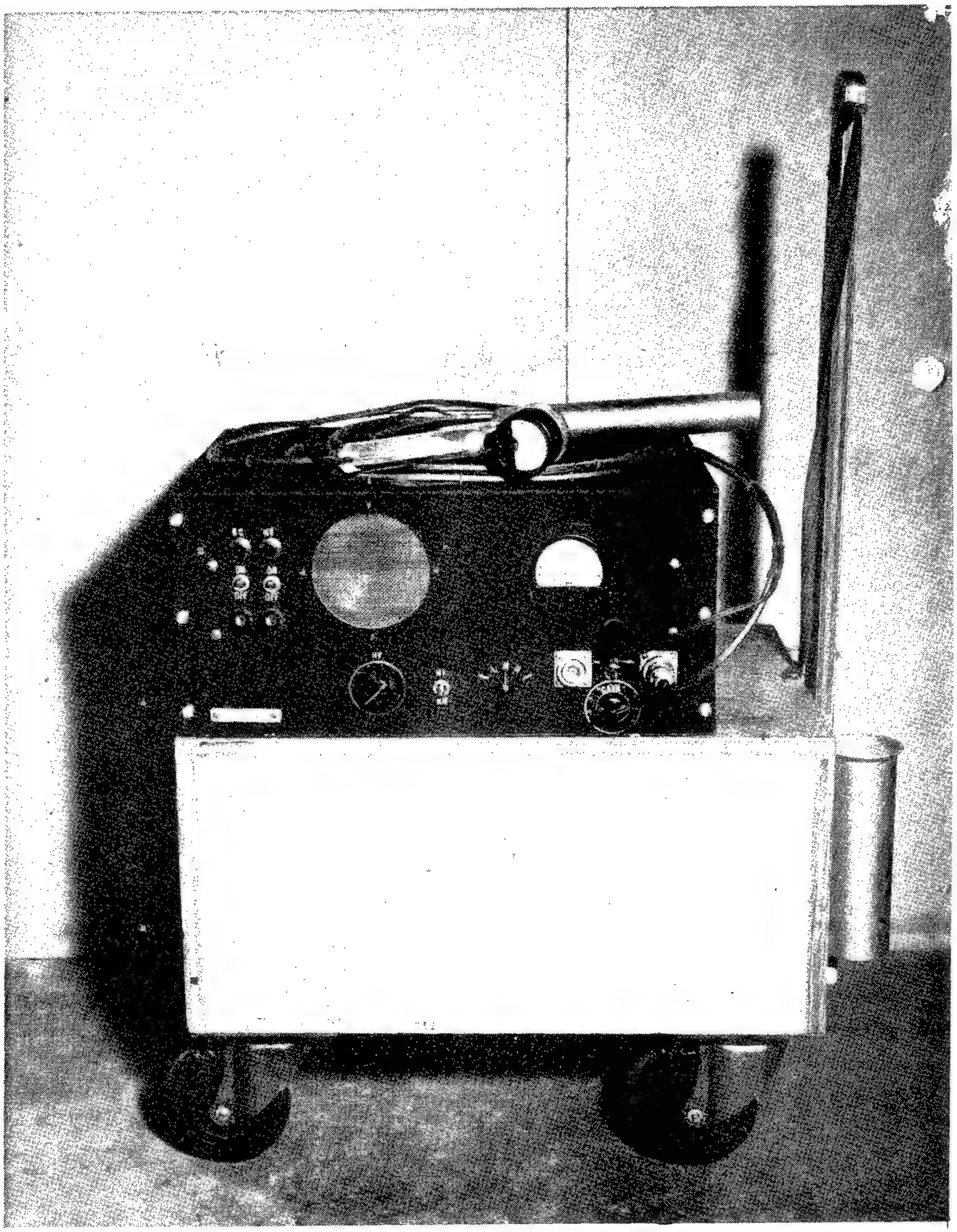

Figure 14.

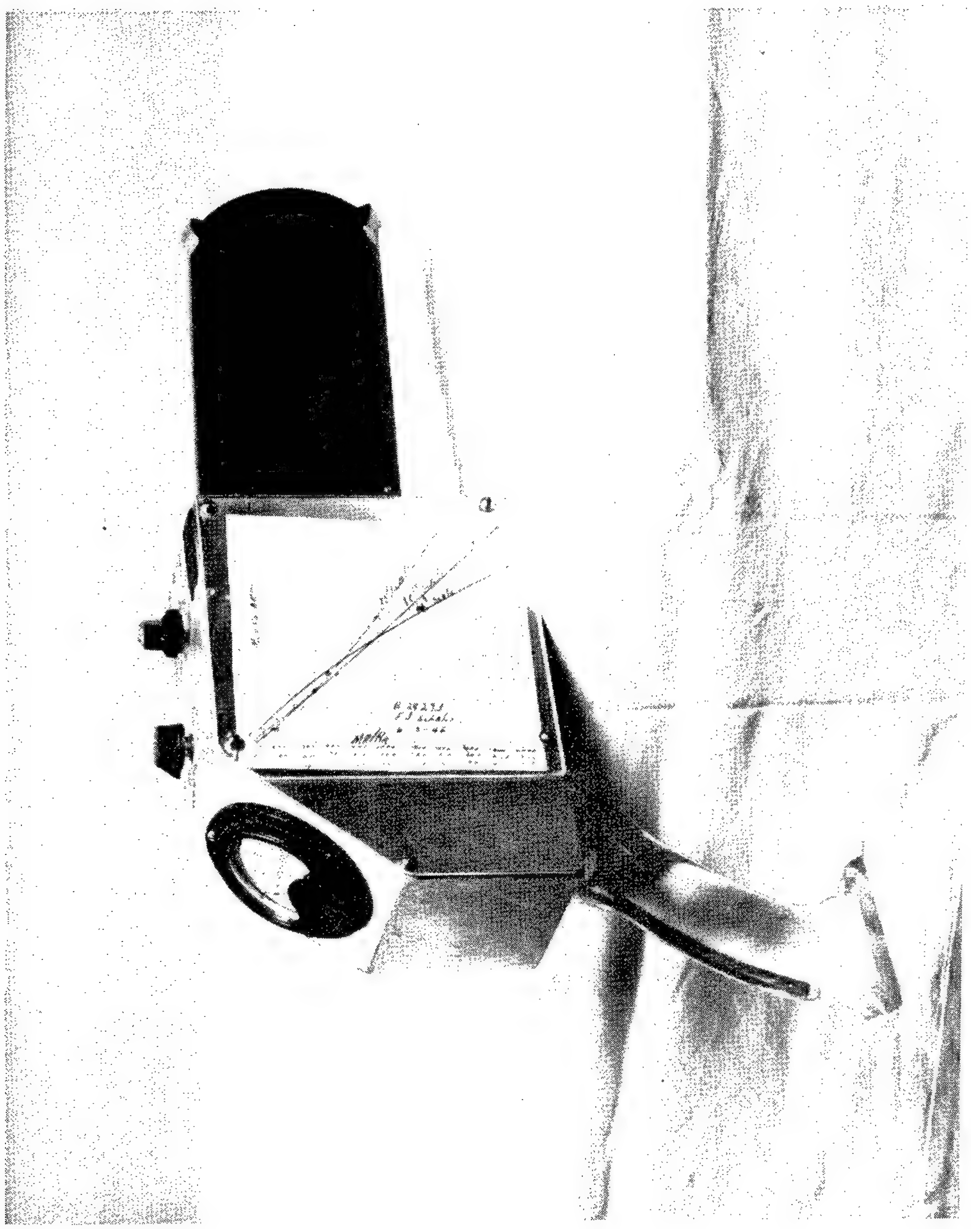

Figure 15.

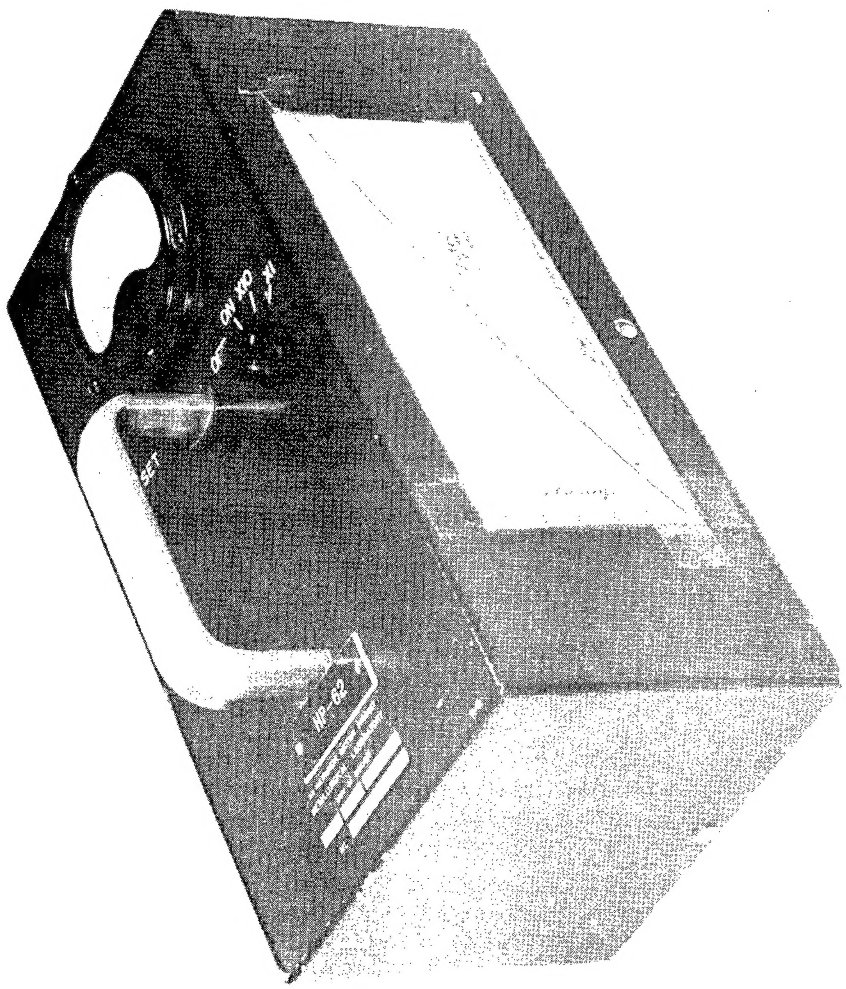

Figure 16.

Hands and feet are the parts of our workers most likely to become contaminated and therefore an instrument has been developed to check hands and feet. The next slide (Figure 17) shows this device. At the start of a check the operator stands on the platform under which 2 counters are located, one under each foot. These counters operate through a scale of 128 to the top register on the right. The top openings in the panel are for the hands and after the employee sets all registers, seen at the top, to zero he places his hands in the openings provided in open positions and presses down to operate the starting microswitches. There are four channels, one on each side of each hand and two counters are used in each channel. The scalers for the hand counters are directly under the hand openings and are scale of 8 as indicated by the three lights in each group. In addition to starting each counting circuit, when the microswitches are thrown by the hands, a timer is also started and when the necessary time has elapsed the circuits are shut off and a green bull's eye lights at the very top of the instrument. Readings are then recorded as shown on the registers. Right back, right palm, left palm, left back, and feet are the words under each register. A small light is visible above each register for the purpose of indicating to the employee whether or not the unit is operating correctly. When hands and feet are clean a count will come up about every 3 or 4 seconds on the register and as it does, the light flashes. This is normal background. If the register does not count, but the lights above them light, it indicates that the register is jammed and the counts are coming too fast for it to operate and this fact keeps the light burning to the human eye whereas it really is flickering too fast to see. Considerable maintenance is required on such units because the Health-Physics people make a daily statistical check on each one of them and they must be absolutely right. We have seven or eight of them in continual operation.

The last slide (Figure 18) shows two of our scale of 64 units being used to check clothing and towels in our laundry. The counter tubes are located in the wooden box under the clothes on the right side of the picture.

I believe that one can see that instrument work in an Atomic Energy Laboratory is a combination of duties with the measurement of radiation our main function. The other work done by the instrument department is much like that done in other chemical process plants and I believe that someday before long many of you will be faced with some problems resembling ours at Clinton Laboratories. Surely the use of radioactive isotopes will branch out into fields of industry as tracer chemicals and I hope that some idea of what will be expected of you as instrument department representatives has been shown in this paper.

I also wish to convey the thought that we are not injuring workers at Clinton Laboratories because of the possible hazards of the work. The contrary is quite true and all the precautions are followed and the understanding of the problem which exists makes the work safe and interesting. Our medical department knows all about our employees since they make regular tests of their physical condition.

I will endeavor to answer questions if time permits which may have come to you in the course of this brief discussion.

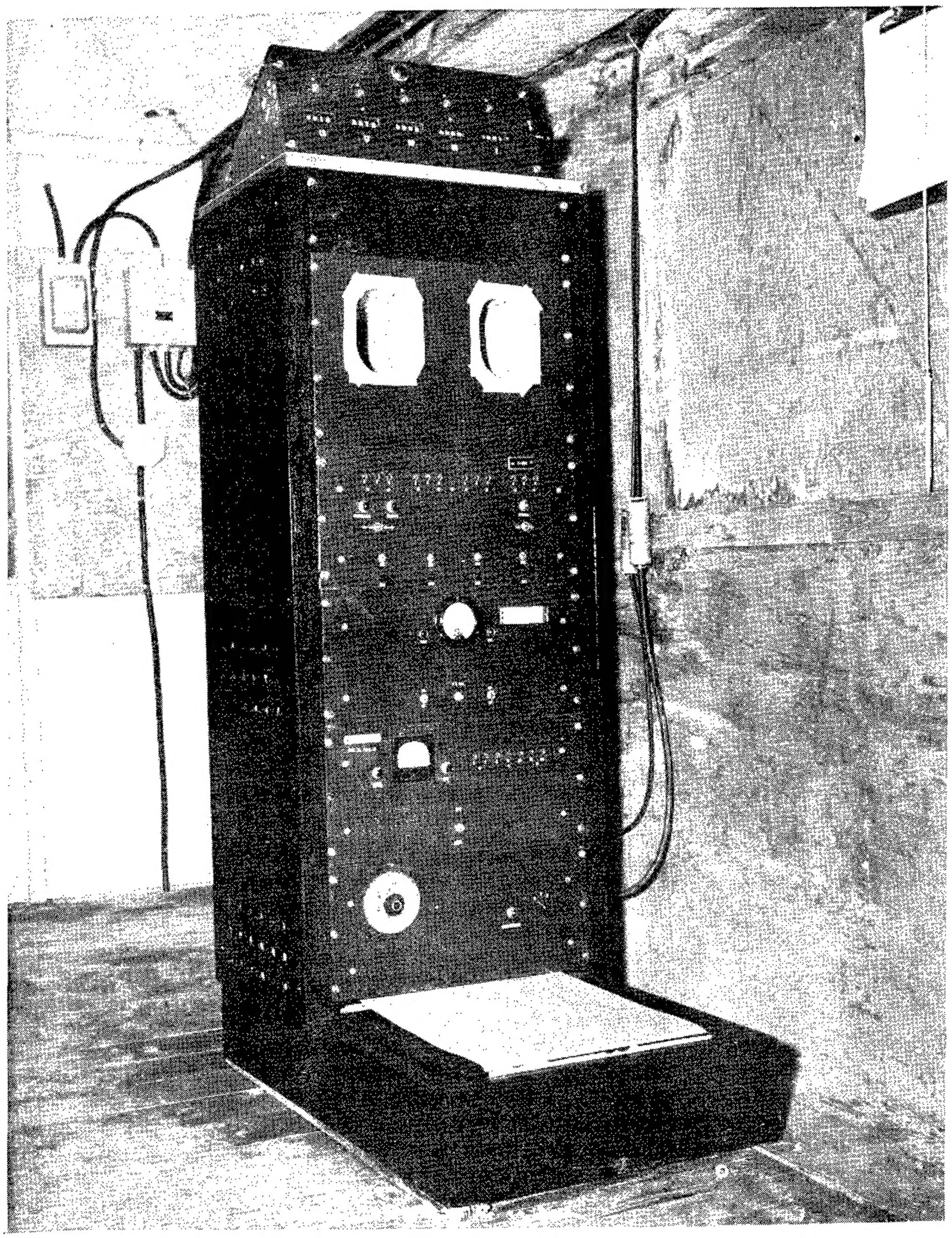

Figure 17.